Optik 125 (2014) 186–190

Contents lists available at ScienceDirect

Optik

journal homepage: www.elsevier.de/ijleo

License plate detection using gradient information and cascade detectors

Runmin Wang*, Nong Sang, Rui Huang, Yuehuan Wang

Science and Technology on Multi-spectral Information Processing Laboratory, School of Automation, Huazhong University of Science and Technology, Wuhan 430074, China

ARTICLE INFO

Article history:
Received 5 December 2012
Accepted 9 June 2013

Keywords:
License plate detection
Cascade detectors
Voting-based method
Gradient information

ABSTRACT

In this paper, we propose a license plate detection method based on the gradient information and a cascade detection framework. The proposed method consists of three main modules: image preprocessing, license plate detection and license plate confirmation. Considering the diversities of Chinese license plate, we first get the gradient images to unify plate forms through image preprocessing. The license plate will be detected roughly by using the cascade AdaBoost classifier in the next step. Finally, several heuristic judgment strategies and a voting-based method are used to verify the candidate license plates. The effectiveness of our method is validated with an experimental study in license plate detection.

1. Introduction

Automatic license plate recognition (LPR) is an important research topic in Intelligent Transportation Systems (ITS), and plays an important role in numerous applications, such as electronic toll collection, traffic activity monitoring, criminal pursuit, etc. In the LPR system, license plate detection is the most crucial step. Many factors affect the detection performance in varying environment, such as license plate distortions, differently sized license plate, uneven lighting conditions and multi-plate detection, etc. It is still a challenging task for us to detect license plates quickly and accurately in varying environments.

Many researchers are committed to the research of license plate detection, and numerous license plate detection methods can be found in literature. These methods range from simple techniques to sophisticated mechanisms. Edge-based approaches [1,2] are the most popular, and the license plate detection rate is relatively high and fast, compared with other methods. However, the edge-based method is too sensitive to noises, and can hardly be applied to complex images. According to the color combination of a plate (background) and character (foreground) is unique, color-based approaches are used to detect the license plates in [3,4]. However, the color-based approaches are not robust enough to different environments, when some regions with similar color with license plate's background, or images taken from a poor illumination, this method may have poor performance. Voting-based strategy is proposed in [5], and some rounds of voting to get license plate in the image. The maximally stable extremal regions (MSERs) information of license plates is used in [6], and the detection results are obtained from some criteria. In [7] the license plates are detected automatically by principal visual word (PVW) and local feature matching. In recent years, some learning-based methods are proposed to detect license plate. Remarkably successful results are reported in [8], where the license plate is detected based on a convolutional neural network (CNN) verifier. An SVM classifier is applied on color texture feature to detect license plates in [9]. and the cascade AdaBoost classifier is used in [10,11].

The core task of license plate detection is to find the license plate location information in the image. The effectiveness and real-time are the two standards to evaluate the detection algorithm. In this paper, a novel license plate detection method based on gradient information and cascade detectors is proposed as a core component for the LPR. Our main contributions include the followings: (1) Different types of Chinese license plate appearance forms are unified through obtaining their gradient images, and then, the license plate is detected roughly by using the cascade AdaBoost classifier scanning across the gradient image at multiple scales and locations; (2) In order to remove the false positives, several heuristic judgment strategies and a voting-based method based on a off-line trained SVM classifier are used; (3) A novel cascade framework is applied to detect the license plate efficiently.

2. Our methodology

A cascade detection framework is adopted to detect the Chinese license plates, Fig. 1 shows the system overview of the proposed approach.

* Corresponding author. Tel.: +86 2787543576; fax: +86 2787543594.
E-mail address: runminwang@hust.edu.cn (R. Wang).

0030-4026/$ – see front matter © 2013 Elsevier GmbH. All rights reserved.
http://dx.doi.org/10.1016/j.ijleo.2013.06.008

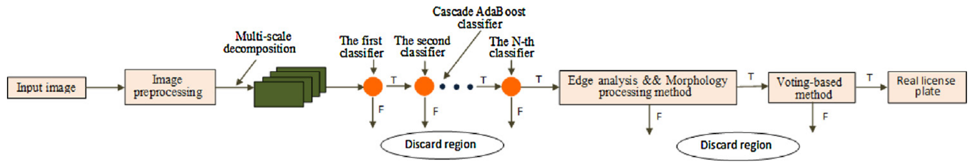

Fig. 1. An overview of our algorithm.

2.1. Image preprocessing

Converting RGB image to gray image, noise elimination, and obtaining gradient image are the three main tasks in image preprocessing. First, the original color image is converted to gray as we do not use color information. And then, the noises are eliminated from the image by using the median filter with 3×3 neighborhood. According to the existing several kinds of vehicle license plates in China, such as blue plates for small civil vehicles, black plates for foreign embassy vehicles, yellow plates for large civil vehicles, and white plates for military police vehicles. These types of license plate appearances are not the same after gray processing, e.g., the gray images of blue plate and black plate are bright text on dark background, and the gray images of yellow plate and white plate are dark text on bright background.

The characters in license plate have obvious differences with its background, we can unify the appearance of the license plate forms through obtaining their gradient images. Meanwhile, the edges can be enhanced and the slow changing background features can be eliminated by using the gradient processing. Detector performance is sensitive to the way in which gradients are computed, but the simplest scheme turns out to be the best [12]. In this paper, we use the gradient operator for horizontal direction is $[-1, 0, 1]$, and the gradient operator for vertical direction is $[-1, 0, 1]$. We apply a grayscale filter and gradient operators on the original color images (Fig. 2(a)) to unify the appearance of the different license plate forms, and Fig. 2(c) shows we can unify the appearance of the different license plate forms through obtaining their gradient images.

In our work, we find the gradient image have stronger classification ability than the gray image for the Chinese license plate. To distinguish the real license plate and the false plate, we select a small number of important features from a very large Haar-like feature pool using AdaBoost. The cascade AdaBoost classifier has 12 strong classifiers, there are 103 operations for the gradient image, but 132 operations for the gray image. The classification performance in every layer as shown in Fig. 3(a), and the number of the weak classifier in every layer as shown in Fig. 3(b). The red rectangular diagram and the yellow rectangular diagram indicate the weak classifier number for the gradient image and the gray image respectively. As we can know from Fig. 3(b), there are less weak classifiers used to distinguish the real license plate and the false plate for gradient image than the gray image.

Fig. 2. Examples of color license plate image, gray image and gradient image.

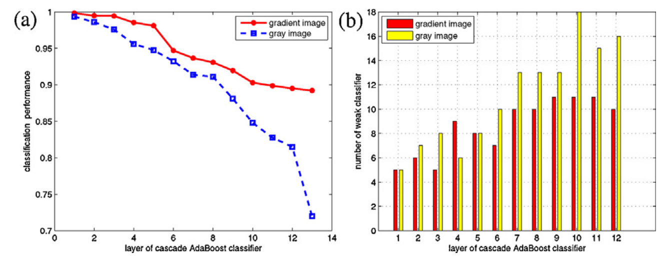

Fig. 3. Classification performance analysis, (a) classification performance in every layer, (b) the number of weak classifier used in every layer.

2.2. Candidate license plate detection

Viola and Jones [13] have introduced a rapid object detection scheme based on a boosted cascade of simple feature classifiers. In their work, a frontal face detection system was developed, which achieved excellent accuracy and nearly real-time speed. Lienhart [14] shows that the Gentle AdaBoost (see Table 1)[15] outperforms (with respect to detection accuracy) Discrete and Real AdaBoost for object detection tasks, while having a lower computational complexity. Motivated by their works, the cascade AdaBoost classifier is constructed by training classifiers using Gentle AdaBoost.

We train the cascade AdaBoost classifier by using 96×26 training samples. Positive sample set includes the license plate images cropped from various kinds of vehicle. Negative samples are the surface of road, roadside trees, parts of vehicle, and many other objects that can be seen on the road. We crop 4734 license plate samples, and the negative samples are collected by selecting random sub-windows from a set of 2042 images without license plates. We train the cascade AdaBoost classier by using the extended Harr-like features except the tilted point feature. The final detector is a 13 layers cascade AdaBoost classifier including 113 features, which scans across every image by shifting the window some number of pixels, and the scales are a factor of 1.05 apart in our experiment. The license plates are detected by using the cascade AdaBoost classifier as shown in the left column of Fig. 6.

2.3. Candidate license plate verification

As shown in the left column of Fig. 6, there are some false positives detected by the cascade AdaBoost classifier. Although increasing the number of layers can decrease false positives, the computational cost will be increased and the detection rate will be

Table 1
Introduction of gentle AdaBoost.

Gentle AdaBoost Algorithm

Step1: Given N examples $(x_1, y_1), (x_2, y_2), \ldots, (x_N, y_N)$ with $x \in R^k$, $y_i \in \{-1, 1\}$.
Step2: Start with weights $w_i = 1/N$, $i = 1, 2, \ldots, N$, $F(x) = 0$.
Step3: Repeat for $t = 1, 2, \ldots T$:
(a) Fit the regression function $f_t(x)$ by weighted least-squares of y_i to x_i with weights w_i.
(b) Update $F(x) \leftarrow F(x) + f_t(x)$.
(c) Update $w_i \leftarrow w_i \exp(-y_i f_t(x_i))$ and renormalize.
Step4: Output the classifier sign $[F(x)] = \text{sign}[\sum_{t=1}^{T} f_t(x)]$.